

Citation for published version:

Trent, A, Liddle, AD, Mellon, SJ, Murray, D, Pandit, H & Pegg, E 2013, 'Development of a method to characterise tibial shape: Implications for the success of the Oxford Unicompartmental Knee arthroplasty', 4th Joint Meeting of the Bone Research Society & the British Orthopaedic Research Society, Oxford, UK United Kingdom, 4/09/13 - 5/09/13.

Publication date:
2013

Document Version
Publisher's PDF, also known as Version of record

[Link to publication](#)

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Development of a method to characterise tibial shape: Implications for the success of the Oxford Unicompartmental Knee Arthroplasty



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Introduction

The Oxford Unicompartmental knee arthroplasty (UKA) is indicated in patients with anteromedial osteoarthritis. Although the Oxford UKA preserves knee kinematics and function more than total knee replacement designs, outcome is variable with comparatively high revision rates reported. Proximal tibial (PT) shape shows considerable natural variation; however, it is unknown whether PT morphology has any impact on the functional outcome of the Oxford UKA.

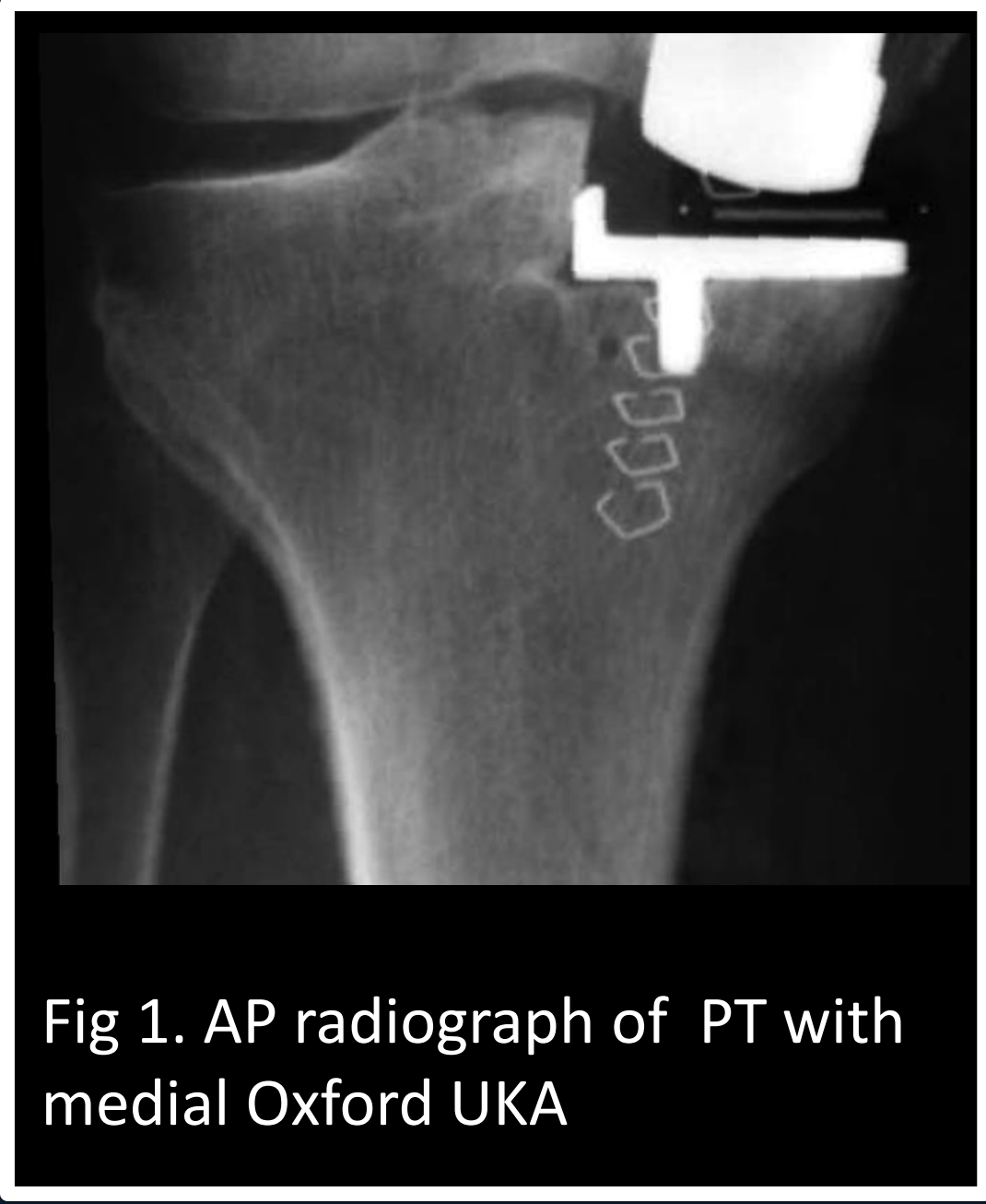


Fig 1. AP radiograph of PT with medial Oxford UKA

Aims

- The aims of the study were threefold:
- (1) to assess the feasibility of using a semi-automated measurement process by comparing Active Shape Modelling (ASM) results to manual measurements.
 - (2) to assess the validity of the characterisation by comparing the resulting distributions to known variation in PT shape.
 - (3) to assess the impact of established variation in PT morphology on functional outcome using the Oxford Knee Score (OKS).

Methods

AP radiographs from 78 patients with 81 medial Oxford UKA, 42 male and 36 female were analysed to characterise PT shape. Manual tibial tray measurements were used to establish radiographic quality. PT shape was characterised according to 7 parameters, 4 dimensional and 3 angular. (Fig 2.)

These were: Total Tibial Area (TTA); Tibial Area Beneath Tibial Tray (TABT); Tibial Width (TW); Tibial Canal Flare Index (TCFI); Lateral Tibial Angle (LTA); Medial Shaft Angle (MSA); Lateral Shaft Angle (LSA)

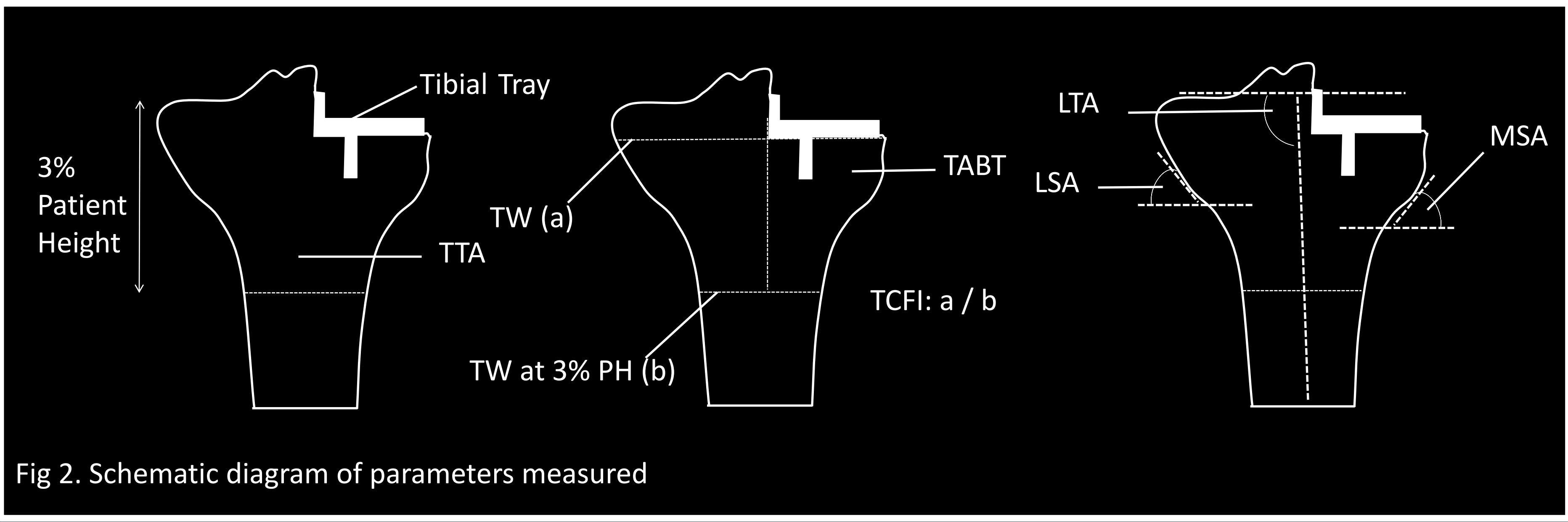


Fig 2. Schematic diagram of parameters measured

Two methods were used to obtain measurements; the first was manual measurement, using Image J software (National Institutes of Health, Bethesda, MD, USA); the second was a semi-automatic method called Active Shape Modelling (ASM). Both intra-observer and inter-observer Intraclass correlation coefficients (ICC) were established to assess the reliability of manual ImageJ measurements. Bland Altman plots and bivariate correlation coefficients were used to assess the correlation between the two measurement methods. Correlation and general linear model regression analysis was performed to analyse the relationship between PT shape and surgical outcome. Surgical outcome was measured using the Oxford Knee Score (OKS).

Results

Results showed a high degree of correlation between ASM and manual measurements, particularly for the area measurements (TTA: 0.908, TABT: 0.922). Angular measurements were more reliably achieved using ASM (Inter-observer ICC LTA: 0.050). Bland-Altman plots demonstrated a consistent deviation in ASM dimensional results suggesting modification of the process is required (TTA MD: 330.37, TABT MD: 99.28) (Fig. 3). The validity of the characterisation was supported by trends in parameter variation according to gender, height, weight and age.

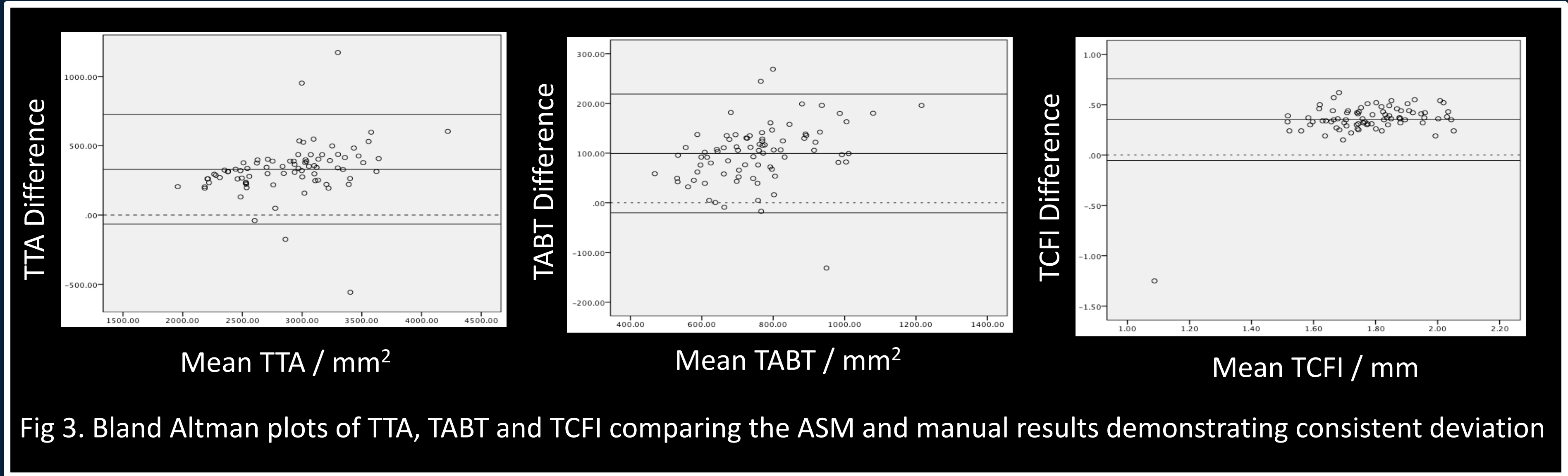


Fig 3. Bland Altman plots of TTA, TABT and TCFI comparing the ASM and manual results demonstrating consistent deviation

Conclusions

This study provides a valid method for the characterisation of PT shape, however, without modification the use of ASM cannot be fully supported for angular measurements. While variation in PT shape is clearly demonstrable, the failure to establish an association between morphology and functional outcome may be due to successful sizing of tibial tray components. This preliminary study had an insufficient sample size for high powered analysis, as calculated using Altman's nomogram.

As such this study should be extended with modifications applied to ASM process, using a larger sample size such that any currently unidentified impact upon outcome may be established and analysis between groups extended. Results of this study suggest that grouping according to gender, and age above and below 60 years may be beneficial.

Regression analysis for individual and combined parameter variation while accounting for age, gender and grouped BMI did not demonstrate a statistically significant impact on success outcomes. When the cohort was divided into those aged >60 and <60 at date of surgery a significant difference was found in OKS-5 outcome with r^2 : 0.153 (p : 0.002) for subjects >60. However this only accounts for a small amount of variability in outcome.